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Interface Heuristics and Style Guide Design:
An Air Battle Management Case Study

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INTERFACE HEURISTICS AND STYLE GUIDE DESIGN:
AN AIR BATTLE MANAGEMENT CASE STUDY

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This paper describes the development of a human-machine interface style guide designed to promote a common look and feel among operator interfaces employed by air battle managers in the United States Air Force, and to reduce training requirements for operators moving between platforms. An analysis of the content of extensive operator interviews from all relevant platforms preceded the production of a compact style guide based on a few simple heuristics and populated with wire frame illustrations devised to act as examples of interfaces that were either compatible or incompatible with each rule. This novel methodology will be discussed as applied to the air battle management work domain, and in the context of its ability to produce usable style guides.

INTRODUCTION

Style Guide Pros and Cons

As defined in the Department of Defense's Joint Technical Architecture (Version 6.0, 2003), "a style guide is a document that specifies design rules and guidelines for the look and behavior of the user interaction with a software application or a family of software applications" (p. 62). The goal of such a document is to enhance performance and reduce training requirements. Ideally, style guides serve as the communication medium by which design rules, standards, and human factors processes are established and shared among system architects, software engineers, and interface designers, thereby ensuring the incorporation of human factors processes into the development of a system (Root, 1993; Shin, 1998). In practice, however, it is naïve to maintain that the mere existence of a style guide is sufficient to guarantee the development of consistent and usable systems.

There are a number of reasons why style guides fail to deliver the anticipated benefits. As pointed out by Gale (1996), the most common reasons for failure include: unspecified governance policies, which often jeopardize content ownership and currency; unstipulated adoption strategy and training, which may result in underutilization or "shelving" of the guide; inappropriate levels of specification; unrealistic expectations of what the style guide can achieve; and, ironically, unwieldy size and Byzantine content organization, which render many style guides unusable. This last point, which can be dubbed the *usability paradox*, is one of the most challenging issues, and possibility the single greatest obstacle for style guide success.

Despite these common failures, style guides are necessary if not sufficient to ensure that interfaces developed by separate design teams for components of a single work domain have a "common look and feel." One such work domain is air battle management. The purpose of this paper is to describe the development of an illustrative style guide for air battle management systems. It depicts the underlying motivation for this type of style guide, the methodological approach employed, and the subsequent design and development of the style guide. The paper concludes with a discussion of the utility of style guides for these types of systems.

The Air Battle Management Work Domain

Tactical command and control (C2) in the United States Air Force (USAF) is performed primarily by the mission crews of two airborne platforms: the E-3 Airborne Warning and Control System (AWACS) and the E-8 Joint Surveillance Target Attack Radar System (JSTARS). Both are Boeing 707 aircraft, the back ends of which have been modified to accommodate a mission crew commander, weapons and surveillance teams, and a handful of computer and communications technicians (Williams, 1997). Although the platforms have very different radars – the AWACS rotating dome radar is used to detect and track fast aircraft, while the JSTARS phased array radar is for detecting, discriminating, and tracking wheeled and tracked vehicles – and hence different missions, there is a considerable overlap in the tasks performed by the mission crews. Moreover, the roles of both crews overlap significantly with those in the Ground Theater Air Control System (GTACS), which essentially serves as a ground-based version of the airborne systems. All three are responsible for the control of tactical assets and the building and sharing of the tactical situational picture (for a more complete description of the air battle management work domain, see Vidulich, Bolia, & Nelson, 2004).

Notwithstanding the similarities in the functions performed by operators on these platforms – indeed, these operators have the same USAF job classification, meaning that they can and do move between the three – there is little commonality between the human-machine interface (HMI) employed at the operator consoles. If an AWACS operator is reassigned to JSTARS, for example, he or she must undergo weeks of training to gain proficiency on the JSTARS HMI. The structure of the Defense acquisition process precludes the mandate for an identical HMI, since the individual air battle management platforms are built by different contractors. However, it should be possible to achieve a "common look and feel" without overspecifying the interface. It is this role that a style guide might profitably fill.

METHOD

Style Guide Gap Analysis

The initial step in developing the style guide was to conduct a literature review on style guide development, and to identify existing style guides and gaps relevant to this application domain. The review resulted in several observations. First, although numerous style guides had been developed for DoD systems and military command and control platforms, many were found to be written at improper levels of specification, either being too general, as in the case of the DoD Human Computer Interface Style Guide (1996), or much too system-specific. Second, regardless of style guide specificity, those reviewed lacked sufficient illustrative content to compliment the design principles and guidelines. Third, many existing style guides fail to provide adequate navigation schemes, hyperlinking, or content indexing. Although this situation is somewhat understandable with regard to paper documentation, many of the electronic and web-enabled style guides did not afford intuitive and suitable navigation among relevant content.

Interviews with Subject Matter Experts

Interviews were conducted with USAF and United States Army air battle managers to develop an understanding of operator roles and responsibilities, platform-specific HMI designs and functionality, and usability issues and challenges associated with these systems. Operators from both AWACS and JSTARS participated in the interviews. Collectively, the participants represented twelve different crew positions and contributed over 20 hours of interview content. The crew positions represented in the interviews included: Mission Crew Commander, Deputy Mission Crew Commander, Air Target Surveillance Supervisor, Air Intelligence Officer, Senior Director, Weapons Director, Sensor Management Officer, Air Weapons Officer, Senior Director Technician, and an Air Operations Technician. Interviews were conducted with one operator at a time while seated at an operator workstation, lasted between 45-60 minutes, and followed a semi-structured script. Two senior human factors specialists and a former AWACS Senior Director conducted the interviews.

Analysis of Interview Content

All interview content was reviewed and categorized in terms of major system functionality, and positive and negative attributes of the HMI. The main system functionality included: situation display design and setup, profile configuration and login, system management, alarms and alerts, voice communications, chat and messaging, combat identification, track management and configuration, and maps. One striking outcome was that there were far more negative observations regarding HMI characteristics than there were positive statements. Upon closer inspection it became clear that the majority of these criticisms and concerns could be categorized according to interface design heuristics (see Nielsen & Mack,

1994). The usability heuristics found most relevant to this content included:

1. *Visibility of System Status* – the system should always keep users informed about what is going on, through appropriate feedback within reasonable time.
2. *Match Between System and the Real World* – the system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms.
3. *User Control and Freedom* – users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue.
4. *Consistency and Standards* – users should not have to wonder whether different words, situations, or actions mean the same thing.
5. *Error Prevention* – interfaces should be designed to prevent errors from occurring.
6. *Recognition Rather than Recall* - make objects, actions, and options visible.
7. *Flexibility And Efficiency of Use Accelerators* – enable expert users through shortcuts
8. *Help Users Recognize, Diagnose, and Recover from Errors* – error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.
9. *Help and Documentation* – supporting documentation should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.
10. *Important Information Prominent Easily Accessed* - place important information in a "dense" interface at the top.
11. *Interfaces Are "Scannable"* – interfaces that are easy to scan share many common characteristics including, use of sans serif fonts, concise self-explaining hypertext, appropriate use of white space for guiding visual search and attention, concise and consistent content.
12. *Responsiveness of System* – well-designed and architected systems can be rendered unusable if response times are excessive.

Illustrative Style Guide Design Strategy

Based on the results of the interviews and the content analysis, a prototype of the style guide was created (see Figures 1a and b, which depicts a typical page from the style guide). The style guide includes major headings and sections that correspond to the major functional areas shared by the air battle management task domain. In this particular example, the section involves the main Situation Display and its overall layout, design, and navigation scheme. Guidelines and rules associated with this section are noted in the respective subheadings included in this section. These rules are intentionally designed to be meaningful and succinct, and are followed by an explanation that describes the

motivation and intent of the rule. Next, illustrative examples of both effective and ineffective information design are provided. The illustrative examples are intended to provide additional clarification of the guidelines and include indexed captions and a concluding summary statement. Lastly, related design principles are provided and are linked to those sections of the style guide.

DISCUSSION

The purpose of this paper proposal was to describe the development of an HMI style guide for air battle management platforms. To be sure, style guides face many challenges, ranging from content management and governance to overall utility and usability. In order to address these concerns an attempt has been made to provide an information architecture and content strategy comprising common functionality, illustrative examples, meaningful and succinct guidelines, and an overall framework based in usability and interface design heuristics. It is believed that this approach, although clearly not ideal, provides considerable promise for resolving many of the difficulties faced by previous style guides.

Although the original intent underlying the construction of the style guide was to provide a set of guidelines for software engineers to use in building HMIs conforming to the desired "common look and feel," as the process has evolved it has become evident that there are other potential uses. The most obvious is perhaps the style guide's utility as a verification tool in the design process, by which program managers and others responsible for acquisition decisions can evaluate delivered products according to their compliance.

ACKNOWLEDGMENTS

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Situation Display: Overall Layout, Design, Navigation

Maximize continuous uncluttered viewing of the Situation Display

The Situation Display is one of the primary sources of situation awareness. The overall HMI should be designed such that the Situation Display is not occluded and that it is continuously viewable to the greatest extent possible. The inclusion of interface elements that diminish the availability of the Situation Display such as pop-up windows, dialog boxes, menu drop-downs, etc. should be minimized.

Effective Information Design

Figure caption. Uncluttered Situation Display

Ineffective Information Design
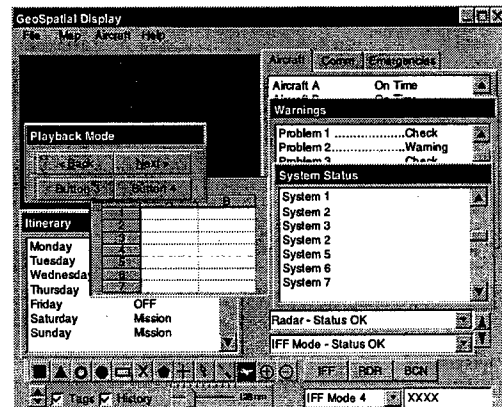
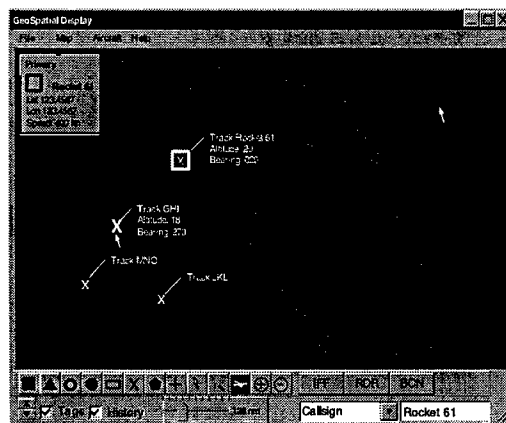Figure caption. Cluttered Situation Display

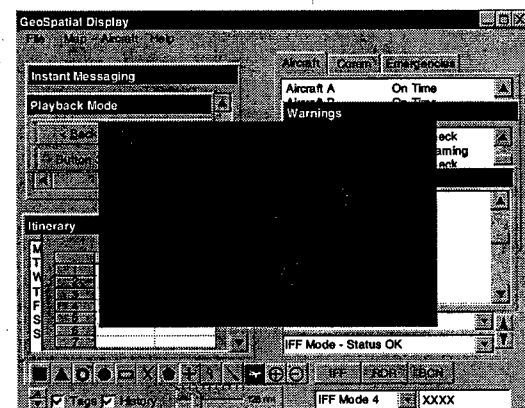Figure caption. Tags and rollovers to minimize clutter and provide direct access to information

Summary

Design uncluttered interfaces using integrated portrayal of mission-critical information.

Figure caption. Indirect information access using multiple windows

Summary

Do not design / architect Situation Displays that prohibit direct, uncluttered access to mission-critical information.

ALSO SEE: Make the Situation Display as "Flat" as Possible

Figure 1a. Example content from the HMI Style Guide. The information architecture comprises 1) a main heading; 2) a subheading containing a design principle; 3) a description of the design principle; 4) illustrative examples (figures) of both effective and ineffective information design; 5) figure captions for each illustrative example; 6) a summary statement that reinforces the intent of the illustrative examples; and 7) links to related design principles and content.

Situation Display: Overall Layout, Design, Navigation

Make the Situation Display as "flat" possible

Lead operators to information in as few mouse clicks as you can. Many BMC2 interfaces are organized in a very linear and hierarchical, requiring users to drill down multiple levels before reaching meaningful content. Utilize user-specified hot-buttons and rollover tags to provide meaningful information to operators in an efficient manner.
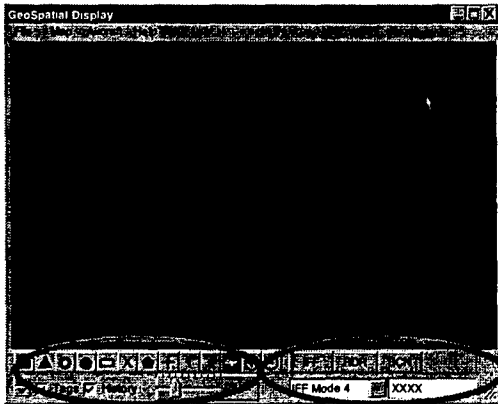
Effective Information Design

Figure Caption. Customizable toolbars and hot buttons for direct manipulation of information
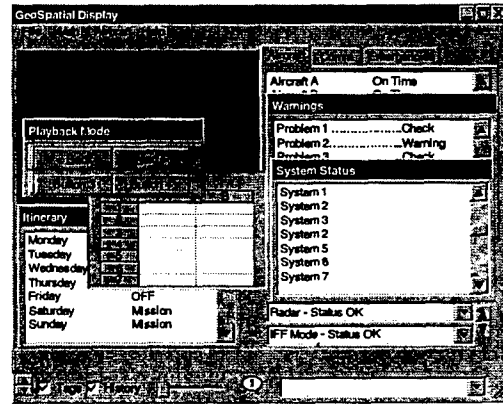
Ineffective Information Design

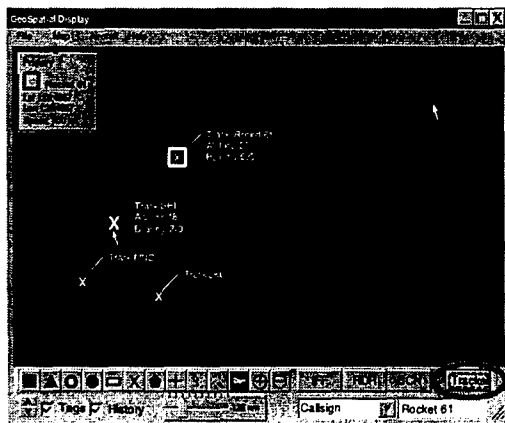Figure Caption. Situation Display without customizable hot buttons and/or toolbars

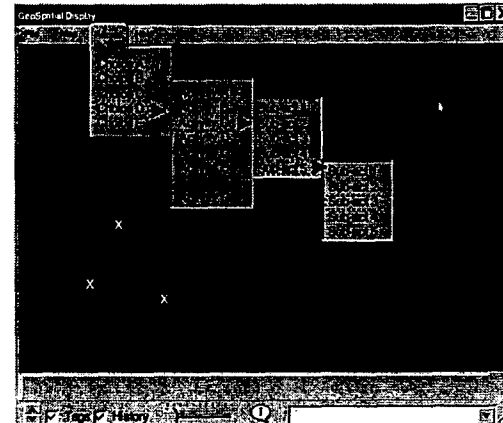Figure Caption. Customized hot buttons used to directly access track information

Figure Caption. Situation Display employing inefficient hierarchical navigation structure

Summary

Design uncluttered interfaces with meaningful information at the primary and secondary levels.

Summary

Do not design / architect interfaces that require excessive user input to acquire meaningful information.

ALSO SEE: Provide Consistent and Intuitive Navigation on the Situation Display

Figure 1b. Additional page of illustrative content from the HMI Style Guide.